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DRAFT

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1 Introduction

1.1 Purpose

This document summarizes mostly the optical measurements performed on sample of the first custom Dual PIN photoDiodes (DPD S8576 Lot 1G) ordered to Hamamatsu with the Specification (LAT-DS-00072-03).

These measurements, previously described in the note Dual PIN photoDiodes Test Plan (LAT-SS-00391-01), are part of their acceptance tests (sensitivity) as well as performance tests (scan). The main aim of these tests is to learn about the characteristics and performances of our Hamamatsu custom DPDs, to upgrade the flight DPDs specification and to prepare and finalize their future acceptance tests.

We describe our experimental setup.

We present our results of:

- Sensitivity of the PIN diodes associated to a comparison with Hamamatsu results,
- Scan measurements of the PIN diodes.

1.2 Definition

1.2.1 Acronyms

GLAST	Gamma-Ray Large Area Telescope
LAT	Large Area Telescope
CAL	the Calorimeter subsystem of the LAT
DPD	Dual PIN photoDiode
NRL	Naval Research Laboratory (Washington, USA)
CEA	Commissariat à l'Energie Atomique (Saclay, France)

1.2.2 Definitions

°C	degree Celsius
µm	micrometer
mm	millimeter
cm	centimeter
pF	pico Farad (10^{-12})
nA	nano ampere (10^{-9})
rms	root mean square

1.3 Documents

LAT-DS-00072-03	' Specification for the Calorimeter PIN Photodiode Assembly', 20 Feb 2001
LAT-SS-00391-01	Dual PIN photoDiodes Test Plan,
SED-GLAST-Y-05-1**-P*	Procédure de mesure des caractéristiques optiques des DPDs
LAT-TD-00444-01	Report of the tests performed on the 50 + 200 first DPDs at Saclay
BaBar DIRC NOTE # 118	The Light generator crate of the DIRC calibration system

2 Description of the Experimental Setup

Our Setup is based on pulsed LEDs associated to optical fibers, a black box, motorized and manual motions and an acquisition system based on NIM, Camac, VME and Labview on MAC (See Fig. 1). The fibers conduct the light to a diffuser for the sensitivity measurements or to a long (50mm) thin (0.5mm inner diameter) collimator for the scanning measurements.

We have two LEDs one green (centered at 525nm with 40nm FWHM) and one red (660nm-20nm) A Microcontrol translation motion with a 175mm range and an accuracy of 0.1mm move the light horizontally (x) in front of the DPD. The DPD is on a support associated to 2 manual micrometer tables for the 2 other y (vertically) and z motions (See Fig. 2).

The DPD is connected to the motherboard of the ev 5093 preamplifier and put in a aluminum alloy Electromagnetic shielding box. Amplifier with adjustable gain gives both a signal for the ADC and another for the trigger via a discriminator.

There are 3 types of acquisition:

- Calibration: using an X-ray radioactive source.
- Sensitivity: Green or Red LED with the diffuser
- Scan: Green or Red LED with the spot collimator.

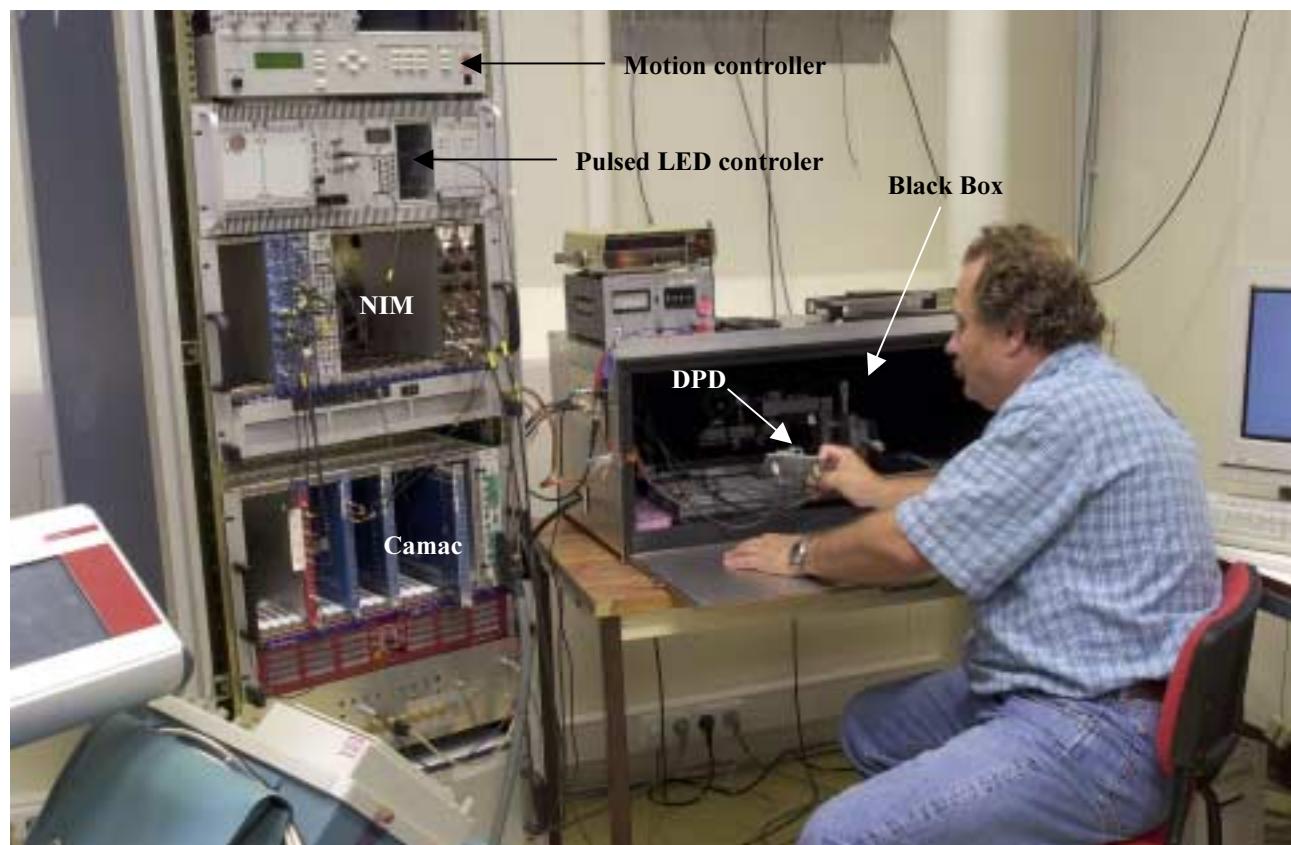


Figure 1: General view of the Experimental Setup.

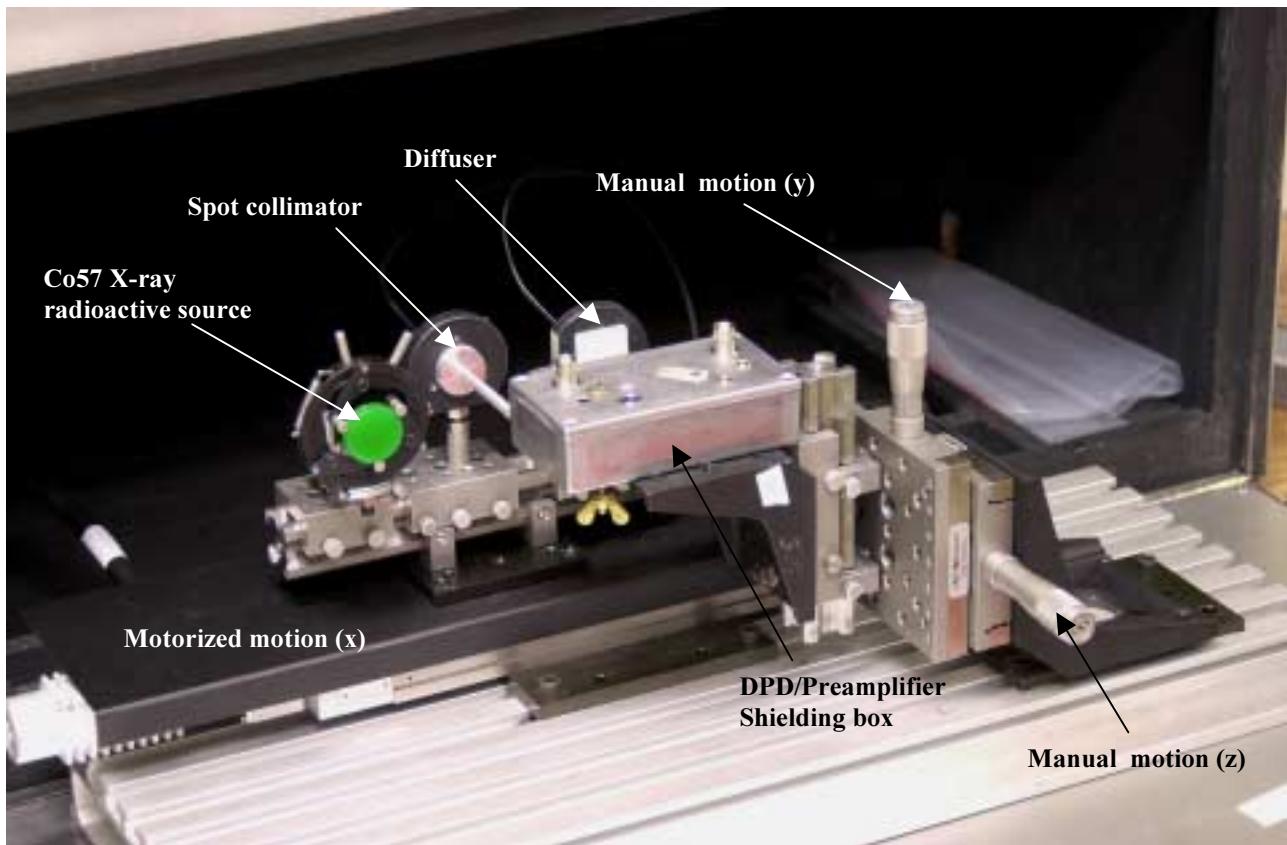


Figure 2: Zoom of the mechanical Setup.

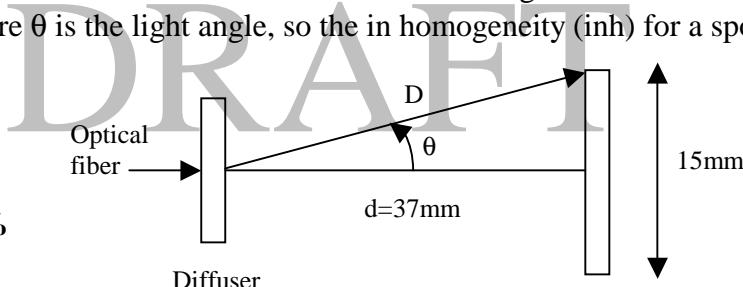
The distance between the diffuser and the Pin is $d=37\text{mm}$. The angular distribution of the light after the diffuser is on $\cos(\theta)$ where θ is the light angle, so the inhomogeneity (inh) for a spot of 15mm diameter is:

$$\text{Inh} = 1 - \cos(\theta)$$

$$\cos(\theta) = d/D$$

$$D = (d^2 + (15/2)^2)^{1/2}$$

$$D = 37\text{mm} \Rightarrow \text{inh}=2\%$$



The distance between the long nose collimator and the DPD window is about 5mm so the light spot is about 0.5mm diameter.

3 Sensitivity measurements

3.1 Setup adjustment

To adjust the position of the diffuser regard to the PIN diode for each one (A & B) we have move the it in front of the DPD and following the PIN Signal. We have checked with the 2 LED (red and green) and 2 DPD (#90 and 100).

The figure 3 shows the results on a graph (red LED, DPD #100). With the 2nd degree polynomial fit we have extract the optimize position of the diffuser in front each PIN.

Notice we have 10mm between the two positions and the distance between the center of the 2 PIN is 11mm.

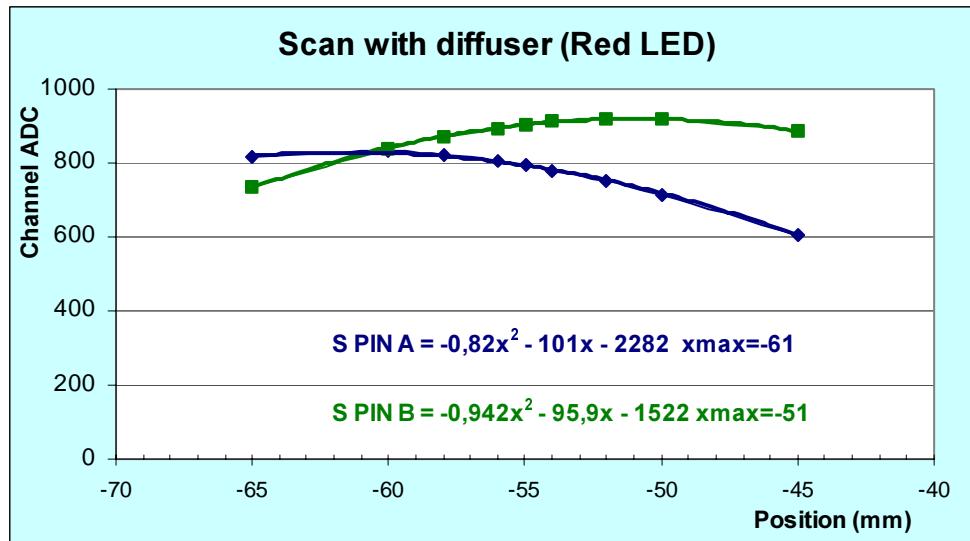


Figure 2: Signal of PIN A & B versus the position of the diffuser.

3.2 Results

The sensitivity measurements have been performed on sampling of DPD from lot 1G (1st order of NRL and 1st order au CEA, 300DDPD). All measurements have not be done at the same time also to monitor the potential variations of the light distribution we have used 2 DPD as Reference to normalize the measurements. The following table 1 summarizes the results on the Reference DPD:

janv-02	Green 520nm		Red 660nm		
	DPD #	PIN A	PIN B	PIN A	PIN B
	100	230	1301	817	909
	100	233	1229	829	895
	100	228	1288	829	918
	100	230	1303	836	938
	100	174*	1200	830	923
	Mean	230	1264	828	916
	sigma	2,1	46,8	6,9	16,0
	%	0,9	3,7	0,8	1,7
	103	228	1314	818	919
	103	232	1314	832	929
	103	225	1296	819	924
	103	223	1287	826	926
	103	210	1227	850	951

Table 1: Measurement variation of the Reference DPD

The Table 2 summarizes the results of the 46 DPD tested. There are first the results for PIN A & B with the green LED in ADC Channel units, and with the red LED. Then, there are the Hamamatsu results in A/W units; and finally our measurements in A/W using the 2 Reference DPD (in blue) for the conversion.

	Green 520nm		Red 660nm		Hamamatsu		Green 520nm		Red 660nm	
DPD #	PIN A	PIN B	PIN A	PIN B	PIN A	PIN B	PIN A	PIN B	PIN A	PIN B
90	226	1303	807	868	0,37	0,38	0,368	0,388	0,361	0,358
91	227	1314	804	903	0,37	0,38	0,369	0,392	0,359	0,372
92	225	1308	806	903	0,37	0,38	0,367	0,389	0,360	0,372
93	220	1284	788	882	0,37	0,38	0,359	0,382	0,352	0,363
94	224	1292	803	904	0,37	0,38	0,365	0,385	0,359	0,372
95	220	1238	793	870	0,37	0,37	0,359	0,369	0,354	0,358
96	223	1274	819	918	0,37	0,37	0,364	0,379	0,366	0,378
97	219	1283	798	890	0,37	0,38	0,357	0,382	0,357	0,367
98	222	1242	793	866	0,37	0,38	0,362	0,370	0,354	0,356
99	220	1308	800	908	0,37	0,38	0,360	0,390	0,357	0,374
100	230	1264	828	916	0,37	0,38	0,375	0,376	0,370	0,377
101	220	1271	791	878	0,37	0,38	0,359	0,379	0,353	0,361
102	225	1266	808	888	0,37	0,37	0,366	0,377	0,361	0,366
103	224	1288	829	929	0,37	0,38	0,365	0,384	0,370	0,383
104	221	1245	808	899	0,37	0,38	0,360	0,371	0,361	0,370
105	221	1297	813	918	0,37	0,38	0,360	0,386	0,363	0,378
106	227	1301	813	907	0,38	0,38	0,371	0,387	0,363	0,373
107	231	1309	827	922	0,38	0,38	0,378	0,390	0,369	0,379
108	225	1301	825	913	0,38	0,38	0,367	0,387	0,368	0,376
109	230	1316	829	929	0,38	0,38	0,375	0,392	0,370	0,383
110	226	1298	823	918	0,38	0,38	0,368	0,387	0,368	0,378
111	231	1331	838	927	0,38	0,38	0,376	0,396	0,374	0,382
112	236	1342	843	929	0,38	0,38	0,385	0,400	0,376	0,383
113	230	1282	818	892	0,38	0,38	0,375	0,382	0,365	0,367
114	229	1303	840	924	0,38	0,38	0,373	0,388	0,375	0,380
115	223	1305	811	910	0,38	0,38	0,364	0,389	0,362	0,375
116	235	1312	841	929	0,38	0,38	0,383	0,391	0,376	0,382
117	227	1339	838	941	0,38	0,38	0,371	0,399	0,374	0,388
118	227	1310	824	914	0,38	0,38	0,370	0,390	0,368	0,376
119	229	1310	824	912	0,38	0,38	0,373	0,390	0,368	0,376
120	223	1274	827	919	0,38	0,38	0,364	0,380	0,369	0,379
121	225	1304	833	930	0,38	0,38	0,366	0,388	0,372	0,383
122	223	1316	832	945	0,37	0,38	0,364	0,392	0,372	0,389
123	224	1252	829	927	0,38	0,38	0,366	0,373	0,370	0,382
124	225	1336	829	930	0,38	0,38	0,367	0,398	0,370	0,383
125	226	1313	804	901	0,38	0,38	0,368	0,391	0,359	0,371
126	219	1244	827	921	0,38	0,38	0,357	0,370	0,369	0,379
157	226	1310	805	900	0,38	0,39	0,368	0,390	0,360	0,371
163	226	1289	811	883	0,38	0,38	0,368	0,384	0,362	0,364
176	227	1325	814	899	0,38	0,38	0,371	0,395	0,364	0,370
187	223	1268	840	930	0,37	0,38	0,364	0,378	0,375	0,383
203	230	1315	813	910	0,38	0,38	0,375	0,392	0,363	0,375
208	230	1315	822	915	0,38	0,38	0,376	0,392	0,367	0,377
242	231	1319	812	881	0,39	0,38	0,377	0,393	0,363	0,363
246	224	1287	771	887	0,38	0,38	0,365	0,383	0,344	0,365
248	225	1295	819	892	0,38	0,38	0,366	0,386	0,366	0,367
287	230	1326	823	917	0,38	0,38	0,375	0,395	0,367	0,378
Mean	226	1296	817	908	0,38	0,38	0,368	0,386	0,365	0,374
sigma	4,0	26,2	15,9	19,5	0,01	0,00	0,007	0,008	0,007	0,008
%	1,8	2,0	1,9	2,1	1,4	0,8	1,8	2,0	1,9	2,1

Table 2: Results of sensitivity measurements on sampling DPD of Lot G

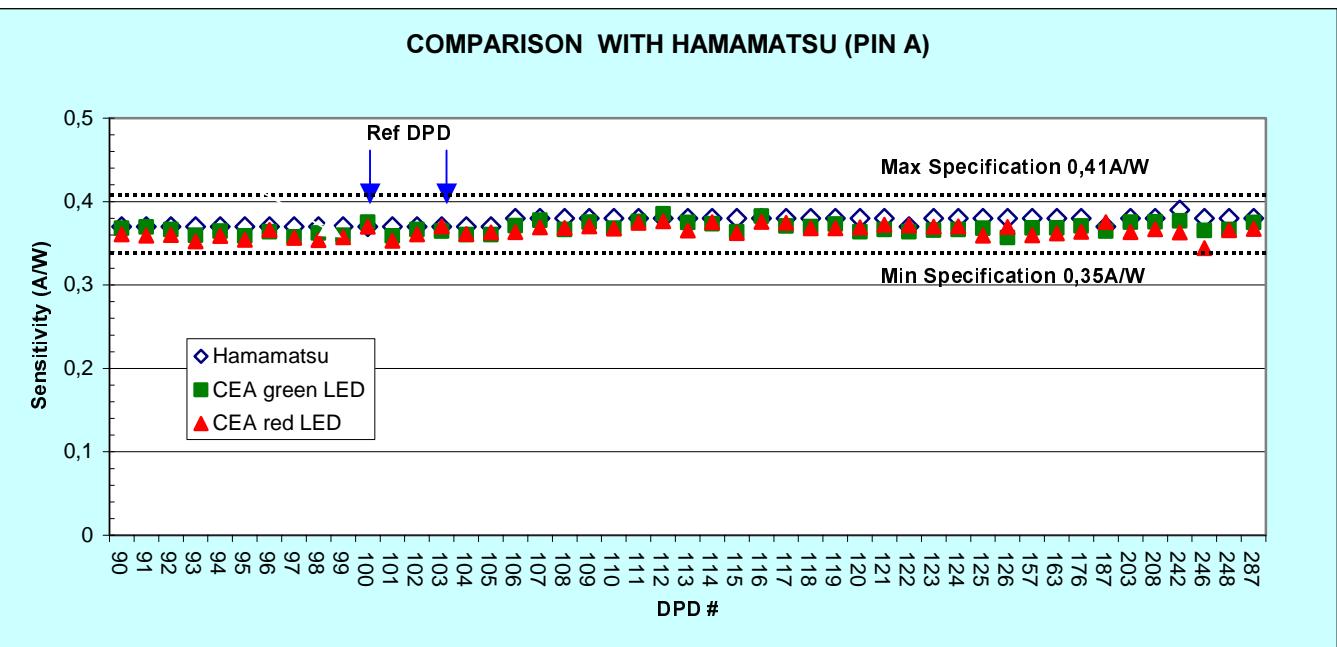


Figure 3: Comparison with Hamamatsu measurements for PIN A.

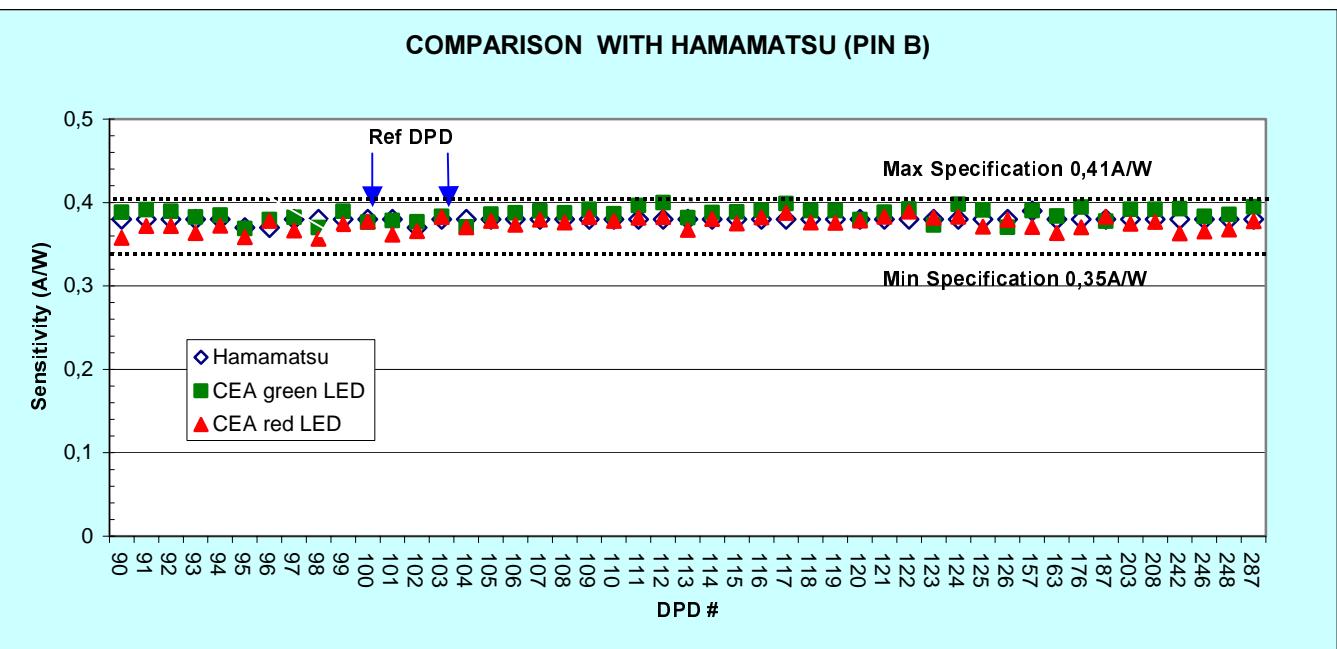


Figure 4: Comparison with Hamamatsu measurements for PIN B.

All our results are in the DPD specification (0.35 to 0.41 A/W), but it seem that our results are more precise: 3 digits instead of 2.

3.3 Hamamatsu Calibrated DPD

We have ordered to Hamamatsu a calibrated DPD (# 2D-721).

We have a concern because there is a big discrepancy between our measurement and Hamamatsu one for PIN A (See Table 3).

The measurements have been performed 6 month later than the previous Table 2, with some moving of the fiber optic so that explain the difference for the reference DPD results in ADC Channel results.

We have redone the measurements, which have confirmed the results. Then, we have also tested the cleaning of the DPD window with alcohol, which has given the same results.

	PIN A			PIN B		
	100	103	721	100	103	721
Hamamatsu	0,37	0,37	0,38	0,38	0,38	0,38
July 2002	0,373	0,367	0,332	0,381	0,379	0,367
Dec 2002	0,368	0,372	0,354	0,379	0,381	0,39
Dec 2002 cleaned	0,373	0,367	0,35	0,379	0,381	0,389
Mean	0,371	0,369	0,345	0,380	0,380	0,382

Table 3: Results of sensitivity measurements on the calibrated DPD 2D-721 in comparison with those of our two references # 1G-100 & 103

4 Scan measurements

4.1 Setup adjustment

The horizontal motion is motorized (17.5cm) and the vertical one is manual (5cmTBC). The Figure 5 gives the orientation of the motion regard to the DPD:

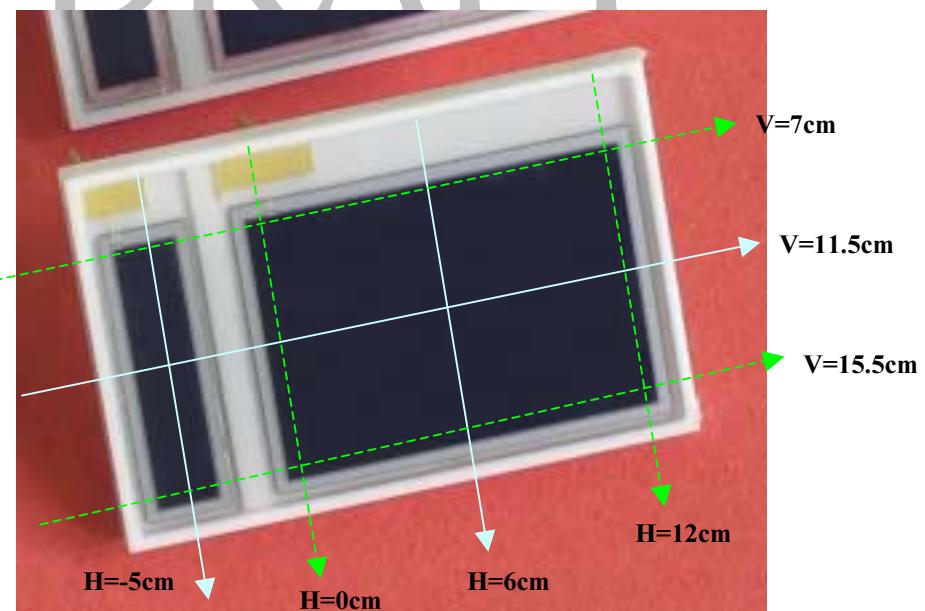


Figure 5: Scan Axes regards to DPD.

4.2 Results

4.2.1 Horizontal scan on 25 DPD

The Scanning has been performed with the red Led (because it is the much powerful), the figure 6 show and example of ADC spectrum and the Figures 7 and 8 show a scan result of respectively the peak position and the FWHM of the peak.

We have performed horizontal scan on 25 DPD, and extract the position of PIN A and B and the width of each PIN as the Full Width at Half Maximum of the distribution. The table 4 summarizes the results and the Figure 9 illustrate the stability of the width results of both PIN A & B.

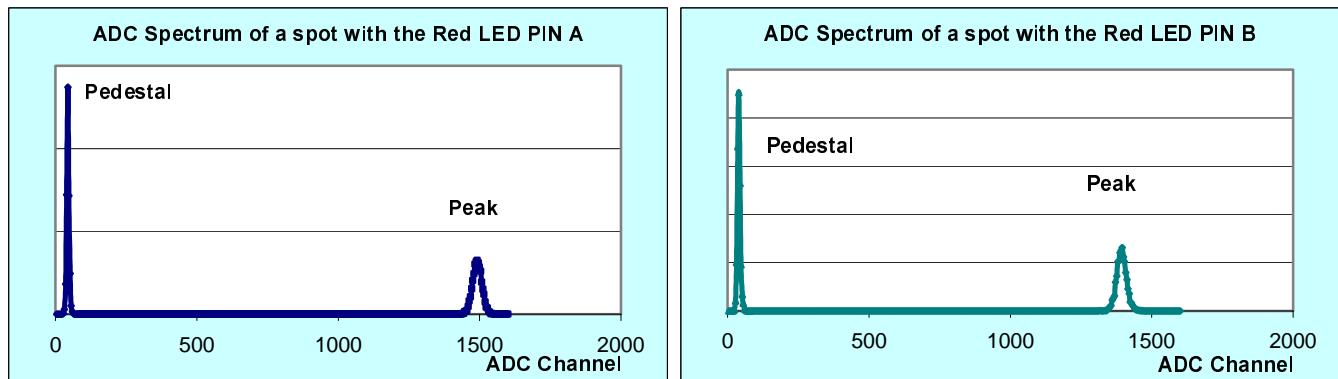


Figure 6: Typical ADC Spectrum of one position of a spot on one of the PIN photodiode.

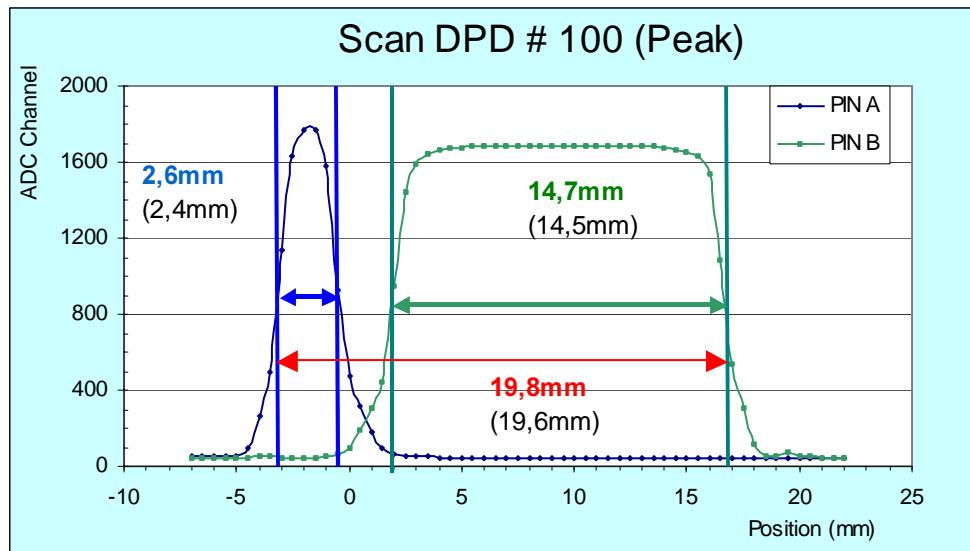


Figure 7: Scan Results on DPD #100 of PIN A & B (in bracket the mechanical values).

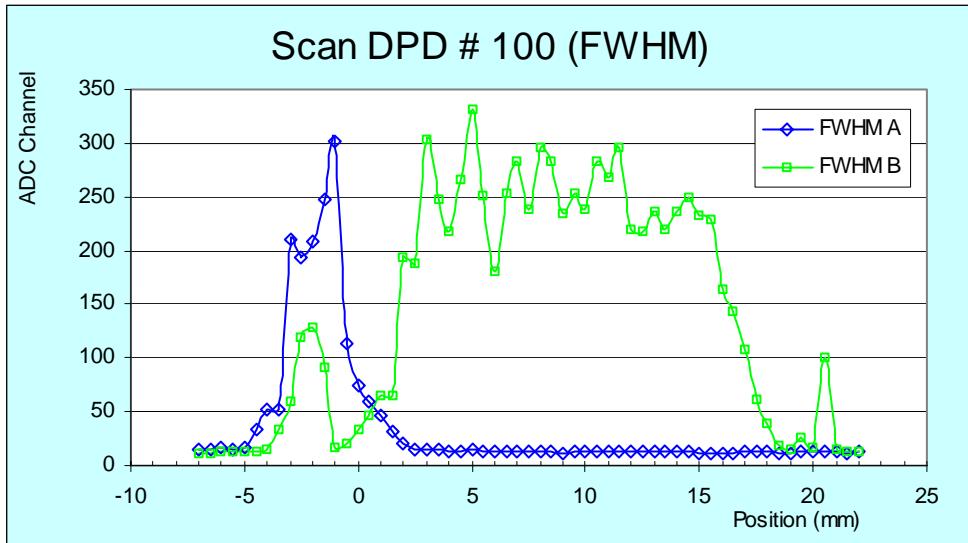


Figure 8: Variation of the peak FWHM along the Scan on DPD #100 of PIN A & B.

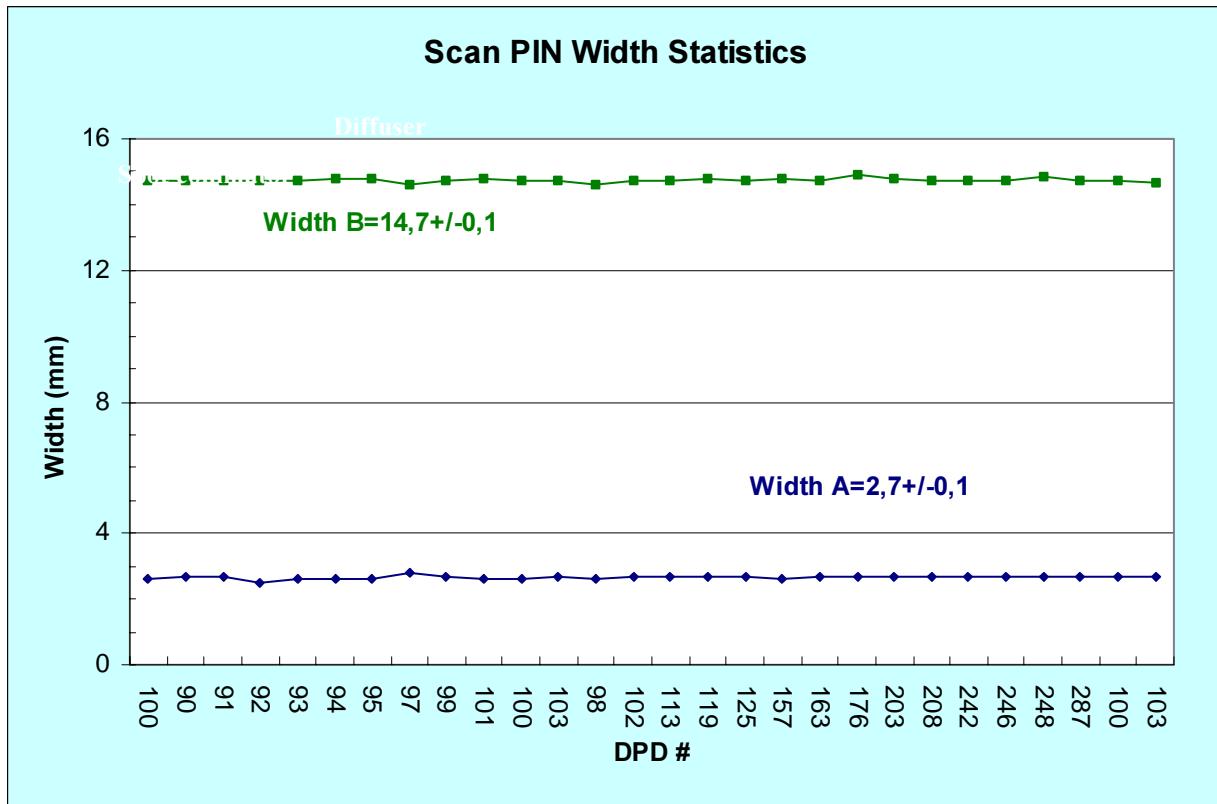


Figure 9: Distribution of the width of PIN A & B obtained with the scan measurements.

On the figure 8, we can see on PIN B, the largest, two peaks on the curve FWHM versus light position, which is systematic but without satisfactory explanation.

Table 9 shows a systematic difference of 0.2mm between the width measured and the expected one, which is the light spot size contribution (0.5mm at 5 mm of the DPD).

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PIN width:	Mechanical values		2,4mm			14,5mm	19,6mm
DPD #	Mean A	Pos A	FWHM A	Mean B	Pos B	FWHMh B	Width A+B
100	1720	-1,75	2,6	1643	9,3	14,7	19,8
90	1726	-1,30	2,7	1660	9,9	14,7	19,8
91	1719	-1,35	2,7	1652	9,8	14,7	19,8
92	1713	-2,20	2,5	1654	8,9	14,7	19,8
93	1695	-1,15	2,6	1643	10,0	14,7	19,7
94	1734	-1,70	2,6	1656	9,5	14,8	19,8
95	1711	-1,75	2,6	1643	9,4	14,8	19,8
97	1709	-1,25	2,8	1635	9,9	14,6	19,8
99	1697	-0,95	2,7	1638	10,1	14,7	19,8
101	1685	-1,55	2,6	1641	9,6	14,8	19,8
100	1712	-1,75	2,6	1627	9,3	14,7	19,8
103	1725	-1,10	2,7	1643	10,0	14,7	19,8
98	1716	-1,05	2,6	1643	10,1	14,6	19,8
102	1724	-1,45	2,7	1640	9,7	14,7	19,8
113	1749	-1,70	2,7	1658	9,4	14,7	19,7
119	1721	-1,00	2,7	1647	10,2	14,8	19,9
125	1709	-1,30	2,7	1638	9,9	14,7	19,9
157	1724	-1,70	2,6	1657	9,4	14,8	19,9
163	1729	-1,25	2,7	1660	9,9	14,7	19,8
176	1737	-1,55	2,7	1681	9,6	14,9	20
203	1759	-1,45	2,7	1686	9,7	14,8	19,8
208	1750	-1,65	2,7	1690	9,5	14,7	19,8
242	1746	-1,45	2,7	1685	9,6	14,75	19,9
246	1735	-1,45	2,7	1682	9,6	14,7	19,9
248	1725	-1,60	2,7	1676	9,4	14,85	19,8
287	1773	-1,70	2,7	1691	9,4	14,7	19,8
100	1773	-1,30	2,7	1669	9,9	14,7	19,9
103	1742	-1,60	2,7	1670	9,5	14,65	19,85
moyenne	1727	-1,47	2,7	1657	9,6	14,7	19,8
sigma	21	0,29	0,1	19	0,3	0,1	0,1

Table 4: Results of scan measurements on 25 DPD of Lot 1G

4.2.2 Horizontal & Vertical Scan of PIN A & B of DPD # 103

See figure 5 to locate the different scans we have done on the DPD #1030.

The Figure 10 , 11a & 12 show 3 horizontal scans at V= 7, 11.5 and 15.5mm.

The Figure 11b shows the variation of the peak FWHM along the horizontal scan at V=11.5mm.

The following Table 5 summarizes the results of the horizontal scan:

V position (mm)	Mechanical	2,4mm		14,5mm	19,6mm
	Mean A	FWHM A	Meanc B	FWHM B	Width A+B
7,0	1389	2,6	1299	14,5	19,6
11,5	1474	2,7	1391	14,7	19,7
15,5	1454	2,6	1352	14,6	19,6

Table 5: Results of horizontal scan measurements on DPD # 103

We measure a size of PIN A & B (FWHM) a little bit greater than the mechanical one because of the convolution with the spot spread.

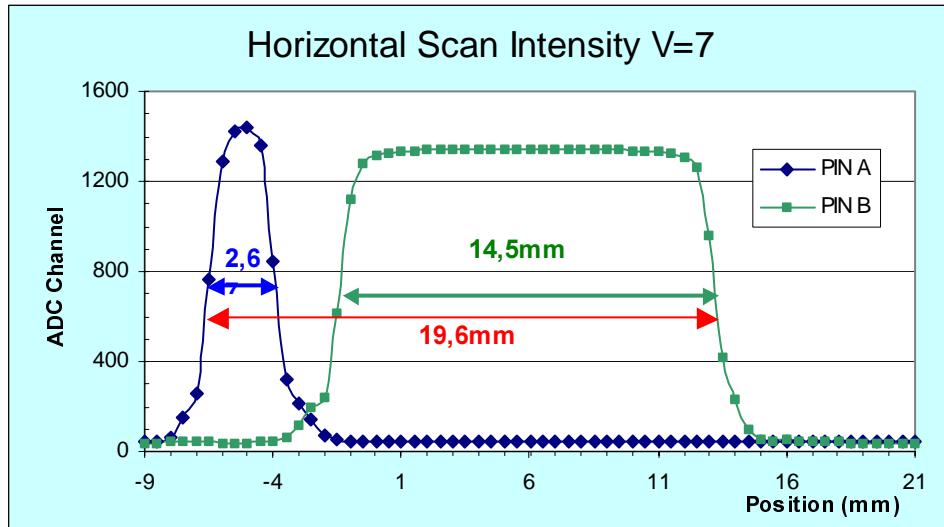


Figure 10: Horizontal scan at V=7mm (edge of the PINs on the side of the wire bondings).

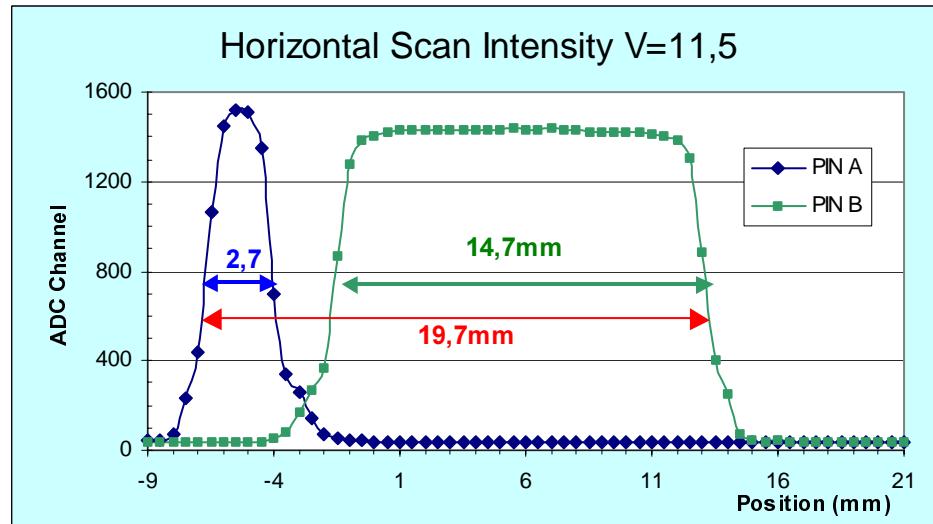


Figure 11a: Horizontal scan at V=11mm (center of the PINs).

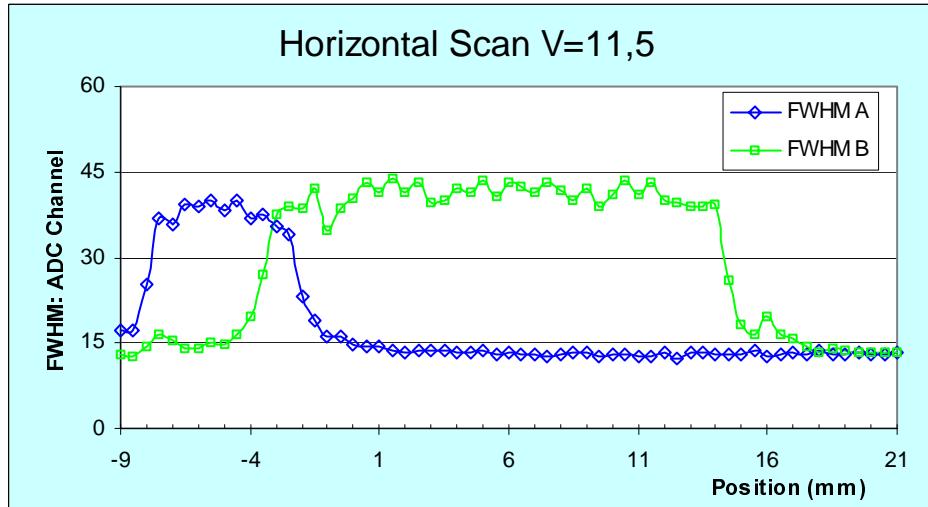


Figure 11b: Variation of the peak FWHM along the Horizontal scan at V=11.5mm (center of the PINs)..

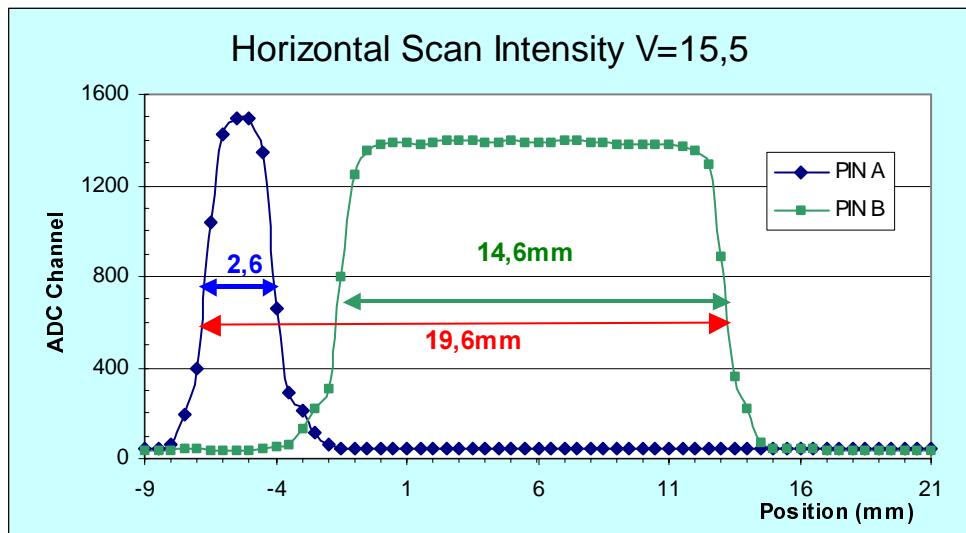


Figure 12: Horizontal scan at V=15.5mm (edge of the PINs on the opposite side of the wire bondings).

4.2.3 Vertical Scan of PIN A & B of DPD # 103

See figure 5 to locate the different scans we have done on the DPD #103.

The Figure 13a shows a vertical scan of PIN A at H= -5mm and 13b the peak FWHM

The Figure 14, 15a & 16 show 3 vertical scans of PIN B at H= 0, 6 and 12mm.

The Figure 15b shows the variation of the peak FWHM along the vertical scan of PIN A at H= 6mm.

The following Table 5 summarizes the results of the horizontal scan:

	H position (mm)	Mechanical	10,5 mm
		Mean	FWHM
PIN A	-5	777	10,7
	0	719	10,8
PIN B	6	728	10,9
	12	705	10,9

Table 5: Results of horizontal scan measurements on DPD # 103

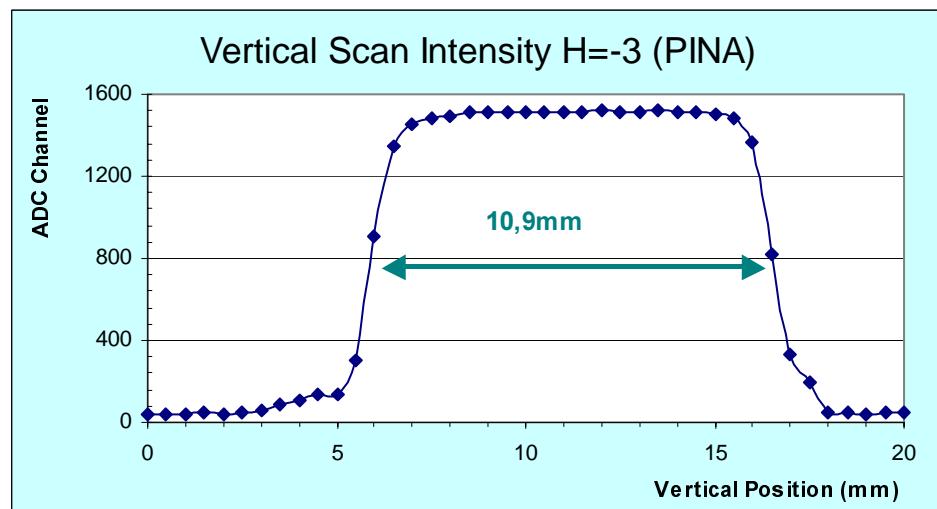


Figure 13a: Vertical scan of PIN A at H=-5mm (center of the PIN).

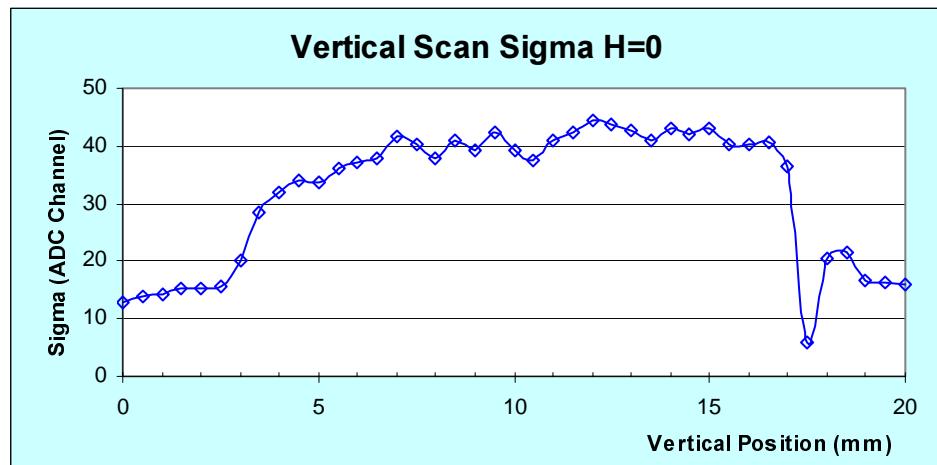


Figure 13b: Variation of the peak FWHM along the vertical scan at H=-5mm (center PINA)

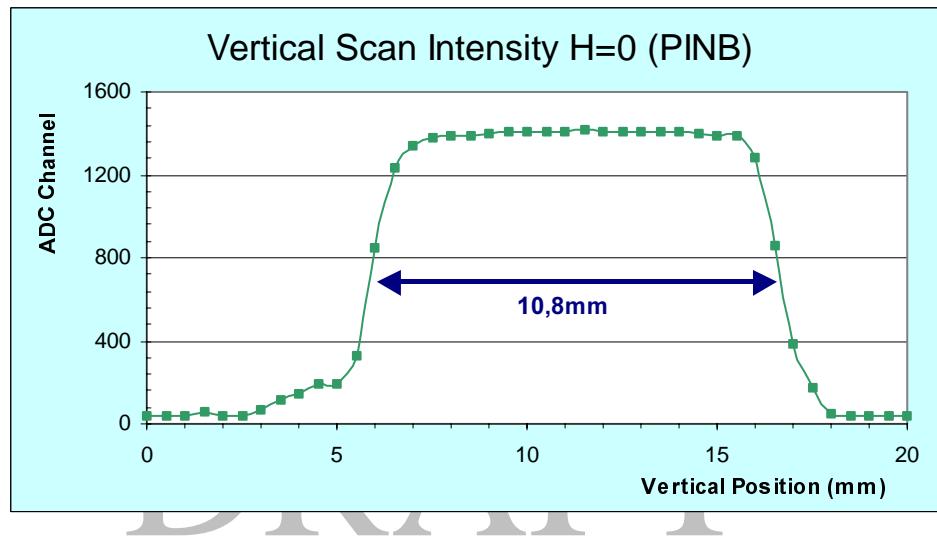


Figure 14: Vertical scan of PIN B at H=0mm (Edge of the PIN).

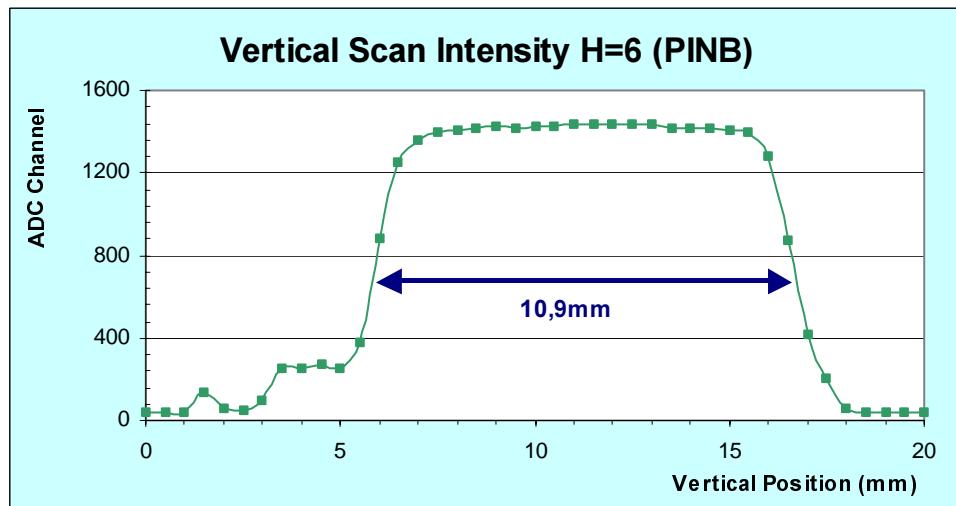


Figure 15a: Vertical scan of PIN B at H=6mm (center of the PIN).

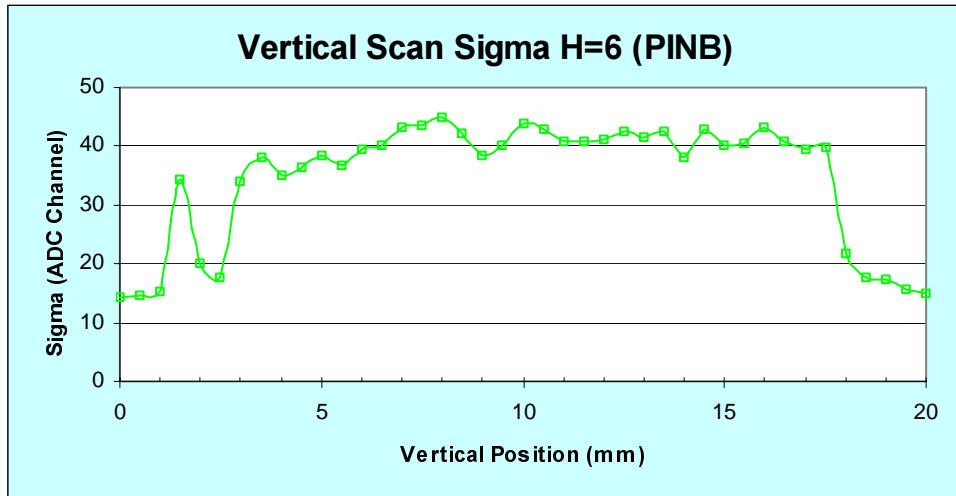


Figure 15b: Variation of the peak FWHM along the vertical scan at H=6mm (center PINB)

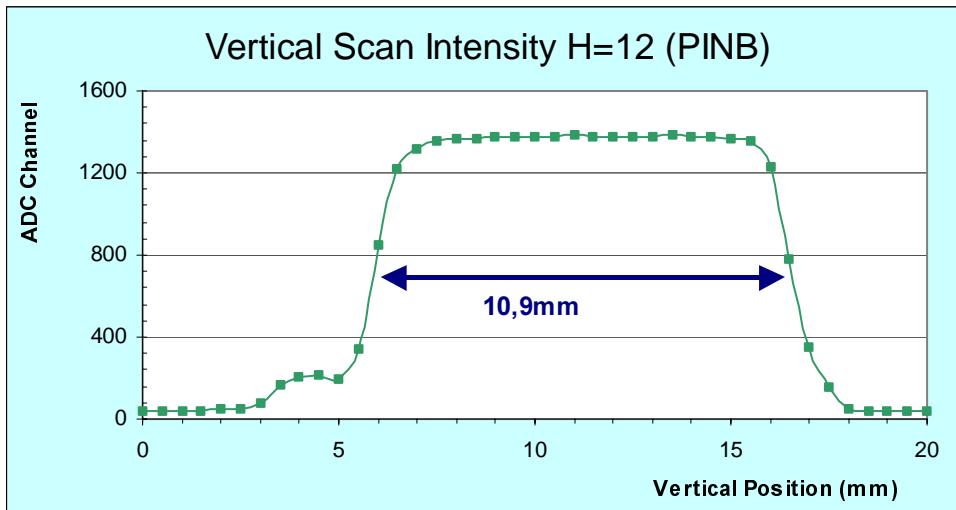


Figure 16: Vertical scan of PIN B at H=12mm (Edge of the PIN).

There is a systematic bump at the position 4mm, which is probably due to reflected light on the white ceramic substrate.

As for the horizontal scan, we measure a size of the PIN (FWHM) a little bit greater than the mechanical one because of the convolution with the spot spread.

5 Conclusions

Our sensitivity measurement with the LED pulsed system allow to have a good agreement with Hamamatsu results, obtained with a continuous lighting. All our results are in the DPD specification (0.35 to 0.41 A/W), but it seems that our results are more precise: 3 digits instead of 2.

Nevertheless we have a concern with the results obtained with PIN A of the calibrated DPD from another lot (2D instead of 1G), we have measured 0.345 instead of 0.38 (10% discrepancy).

The scans of the PIN have given very good results, both for the PIN A & B homogeneity and the DPD sample one.